Acentech Report No. 0393
AI Project Number 620120

Fox Islands Wind Power Project
Vinalhaven Island, Maine
Construction, Operation, and Maintenance Noise Impact Assessment

James D. Barnes
Eric W. Wood

March 2009

Submitted by:

Acentech Incorporated
33 Moulton Street
Cambridge, MA 02138

Prepared for:

Fox Islands Wind, LLC
c/o Fox Islands Electric Cooperative
Main Street
Vinalhaven, ME 04863

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1. Introduction

Fox Islands Wind, LLC ("Fox Islands" or the "Applicant") proposes to construct, operate, and maintain three wind turbine generators each rated at 1.5 MW at an elevated site near the center of Vinalhaven Island, Maine and is applying for all necessary federal, state, and local permits and approvals. The Applicant is working together with the Fox Islands Electric Cooperative and the Island Institute to promote on-island sustainable development while reducing the Island's dependence on fossil fuels and electricity that is now imported from the mainland via undersea cable.

Recent studies conducted on Vinalhaven Island have documented that the local wind resource at 80 meters above the site together with the three proposed grid-scale utility-grade wind turbines operating at the site should be capable of producing approximately 11 million kilowatt hours of electric power annually. This is approximately equal to the current annual on-island electricity use.

Wind turbines produce no electricity and no noticeable sound when the wind speed at the turbine is less than about 7 mph (what is called the cut-in speed). As the wind speed at the turbines increases above about 7 mph, the electricity produced and the sound generated by the turbines both slowly increase. Previous studies and our common experience demonstrate that background ambient sound levels also increase when local wind speeds increase.

This report addresses the expected sound during construction, routine operation, and maintenance of the three wind turbine generators proposed for Vinalhaven Island. Sections 2 and 3 of this report describe the existing site area and define applicable sound level requirements. Section 4 presents the baseline ambient sound levels measured near the Project site. Sections 5 and 6 describe the sound that will be produced during construction, operation, and maintenance of the Project. Noise mitigation is addressed in Section 7. The noise impact associated with the Project is assessed in Section 8 where it is concluded that the sound produced by regulated equipment will comply with all applicable sound limits. Conclusions are summarized in Section 9.

Appendix A describes sound in lay terms and defines various technical terms used in this report, for the convenience of the reader.

2. Site Description

The Project site, shown in the Figure 1 aerial photograph, is at an elevated location approximately 3.4 miles northwest of the Vinalhaven town center and along the southwest side of North Haven Road, and to the west of where Mills Farm and Company Point Roads extend from North Haven Road. Several miles to the north is nearby North Haven Island. The site and adjacent lands are mostly densely wooded with evergreen trees and occasional granite outcroppings. Figure 2, an expanded view of the Figure 1 aerial photograph, shows the

locations of the three proposed wind turbine generators and 16 residences (not including the one being bought by the Applicant) located in the vicinity of the site. The nearest house that will not be owned by the Applicant is approximately 1240 ft from the nearest turbine; all others are more than 1500 ft distant from the wind turbine towers.

Figure 3 presents a representative sketch showing the various elements of a wind turbine generator. The wind turbine hubs and electric generators will be mounted on three tubular-steel towers extending approximately 250 ft above local grade. The wind turbine rotor blades to be mounted at the hub will be approximately 120 ft long. An electrical transformer will be located onsite at ground level to transmit electricity from the generators to the existing distribution grid.

3. Noise Regulation Requirements

No federal noise regulations are applicable to the off-site environmental sound associated with the construction, operation, or maintenance of the proposed Project.

The Town of Vinalhaven relies upon noise standards established by the State of Maine Department of Environmental Protection as described below.

Chapter 375.10 of Maine's Site Location of Development Law Regulations includes the following noise standards applicable to the off-site sound produced during routine operation of regulated equipment for the proposed Project.

- Hourly equivalent operating sound level limits of 60 dBA during daytime hours from 7 a.m. to 7 p.m. and 50 dBA during nighttime hours from 7 p.m. to 7 a.m. at protected locations in areas where the zoning is not predominantly commercial or industrial.

- Hourly equivalent operating sound level limits of 55 dBA during daytime hours from 7 a.m. to 7 p.m. and 45 dBA during nighttime hours from 7 p.m. to 7 a.m. at particularly quiet protected locations where the pre-development ambient hourly sound level is equal to or less than 45 dBA during the daytime period and/or equal to or less than 35 dBA during the nighttime period.

- Hourly equivalent operating sound level limits of 70 dBA during daytime hours from 7 a.m. to 7 p.m. and 60 dBA during nighttime hours from 7 p.m. to 7 a.m. at protected locations in areas where the zoning is predominantly commercial or industrial.

- Hourly equivalent operating sound level limit of 75 dBA at the Facility property boundary.

Sources of sound exempt from the above limits include safety and protective devices and warning signals, construction operations from 7 a.m. to 7 p.m. or during daylight hours, whichever is longer, and registered and inspected motor vehicles that enter the site to make a delivery or pickup, but not when parked at the facility with the engine running for more than 60 minutes.

No other regulations are applicable to the off-site environmental sound associated with the construction, operation, or maintenance of the proposed project.

4. Measured Baseline Ambient Sound

The above regulations do not require pre-development baseline ambient sound levels to be measured or reported. However, such measurements were made and are presented here for informational purposes.

The baseline ambient sound was measured continuously with calibrated sound level monitors at two locations near properties adjacent to the Project site. The monitors measured continuously and recorded the existing ambient equivalent A-weighted fast-response sound levels for two weeks from midday on 23 October to the late-morning of 7 November 2008. In addition, wind speeds were measured continuously during the baseline sound measurements. The sound measurement positions were selected based on the following general criteria aimed at identifying areas where the routine project operating sound might be heard.

- Measurements were obtained adjacent to residential areas because people are generally most sensitive to sounds at their homes.

- Measurements were obtained adjacent to the residential areas closest to the Project Site where the Project sound might be heard at a neighboring home.

The sound level monitors were field calibrated just prior to and directly following the measurements. In addition, the monitors had been laboratory calibrated within 12 months prior to the measurements. The instruments used for the measurements are identified in Table 1.

Weather conditions during the sound measurements included daytime high temperatures ranging from 43 to 63 degrees F and nighttime low temperatures ranging from 23 to 53 degrees F. Sky conditions ranged from sunny to overcast and fog. Average hourly wind speeds ranged from calm to 11 mph. Stormy conditions with high wind speeds and/or significant rain occurred during 25, 26, 28, and 29 October 2008.

Sound and wind speed measurements were made at location 1 (shown on Figure 2), which is within a clearing adjacent to a residence to the south of the Project site. Sound measurements were made at location 2 (also shown on Figure 2), which is within a wooded area near an unoccupied residence on the Applicant's site.

Hourly equivalent sound levels measured at both positions throughout the two-week period are shown in Figure 4. Also shown in Figure 4 are the hourly average and hourly gust wind speeds (right-hand scale) measured during the two-week period at location 1. Figure 5 presents the same measured baseline data after removing 1) the measurements made during the stormy conditions on 25, 26, 28, and 29 October 2008 and 2) the measurements made during periods with nearly calm wind speeds less than 2 mph, conditions when the wind turbine generators are not apt to operate.

The sound level data measured at locations 1 and 2 and shown in Figure 5 have been analyzed so as to also calculate the daytime equivalent sound level (7 a.m. to 7 p.m.) and the nighttime equivalent sound level (7 p.m. to 7 a.m.) for both locations. The daytime and nighttime ambient hourly sound levels were computed by arithmetically averaging the daytime and nighttime values of the measured one hour equivalent sound levels after multiple values for specific hours were first energy averaged, in accordance with Maine DEP Regulation Chapter 375.10 Section H, §3, §3.1.

These daylong and nightlong equivalent sound levels are listed below. They represent the average sound level throughout the daytime periods and the average sound level throughout the nighttime periods that were measured at both locations during moderate weather conditions without storms and without calm wind conditions.

Daytime and Nighttime Equivalent Predevelopment Baseline Ambient Sound Levels Measured without Storm or Calm Wind Conditions.

Measurement Position	Daylong Equivalent Sound Levels from 7 a.m. to 7 p.m.	Nightlong Equivalent Sound Levels from 7 p.m. to 7 a.m.
1	42 dBA	37 dBA
2	38 dBA	37 dBA

hourly average wind speeds from 2 to 7 mph (see Figure 5)

At location 1, the daytime and nighttime average equivalent sound levels were 42 and 37 dBA, respectively. At location 2, the daytime and nighttime average equivalent sound levels were 38 and 37 dBA, respectively. The measured data presented above represent, and are considered to be typical of, the existing ambient sound environment adjacent to the proposed project site during times when the wind turbine generators can be expected to operate. The measured ambient sound levels reported here are similar to the sound levels found in lightly-populated areas.

5. Project Construction Sound

Construction of the wind turbine generator project is expected to extend over an approximately three to four month period. Initial construction activities will include site improvements and construction of the facility access road; then clearing, excavation, foundation, and backfill work at the site. This will be followed by delivery of equipment and materials, erection of the towers, installation of the wind turbine generators; trenching and installation of the electrical collection system, and installation of substation equipment. Finally, prior to commercial operation, the individual equipment items will be tested and commissioned.

A majority of the construction activities associated with the proposed project will be conducted during daytime hours from 7:00 a.m. to 7:00 p.m. or daylight hours whichever is longer. Nighttime construction activities after the hours above are not anticipated. Any construction at the facility in the evening and nighttime is expected to be limited to relatively quiet activities.

Typical on-site equipment used during construction will include trucks, dozers, excavators, loaders, graders, backhoes, cranes, compressors, pumps, generators, and welders. Representative workday equivalent sound levels associated with construction equipment are listed in Table 2. The sound levels shown in Table 2 are based on the results of extensive previous acoustical studies of engine-powered construction equipment.

Construction equipment sound levels are presented here for informational purposes. The sound from construction equipment during daytime hours is exempt from limits in the Maine DEP Noise Regulation. But all equipment used in these activities on Vinalhaven Island will comply with any applicable federal noise regulations, and will include noise control devices in proper working condition and maintained as originally provided by the equipment manufacturer.

The following mitigation measures will be employed during the construction phase of the project:

- Effective exhaust mufflers in proper working condition will be installed on all engine-powered construction equipment at the site. Mufflers found to be defective will be replaced promptly.

- Construction contractors will be required to ensure that their employee and delivery vehicles are driven responsibly.

- Nighttime construction work that does occur will be limited to relatively quiet activities, such as welding and installing equipment, cabling, and instrumentation.

- The community will be notified in advance of any blasting activity at the Project site.

Construction activities will sometimes be audible to nearby residents. Construction sounds heard off-site will vary from hour-to-hour and day-to-day in accordance with the equipment in use and the operations being performed at the site. Since the construction activity at the site will be temporary, will occur mostly in the daytime hours, and will be similar to sounds from other construction projects, its overall impact is not expected to be significant.

6. Project Operation and Maintenance Sound

Sound associated with routine operation of the proposed Project will be produced by A) the on-site electrical transformer 24-hours per day and B) by the wind turbine generators when wind speeds at the turbine hub elevation are in the range of approximately 8 to 50 mph. During lower and higher wind speeds the wind turbines will not operate and can be expected to produce no noticeable sound.

Presented in the following table for the nearest noise-sensitive receptors are the ranges of expected hourly equivalent operating sound levels from regulated equipment during future operation of the proposed project with low to high wind speeds. The expected operating sound levels are based on manufacturer's data and the distances between each wind turbine and the

nearest noise-sensitive receptors. The expected sound levels are, of course, lower for locations that are farther from the proposed Project.

Residential Locations Shown in Figure 2	Expected Operating Sound Levels, dBA Low/High Wind Speeds	Maine DEP Sound Level Standard, dBA Nighttime Periods
A	38/46	50
B	36/44	50
C	36/44	50
D	36/44	50
E	37/45	50
F	35/43	50
G	34/42	50
H	33/41	50
I	32/40	50
J	33/41	50
K	30/38	50
L	30/38	50
M	30/38	50
N	28/36	50
O	33/41	50
P	32/40	50

The Project will be designed and operated such that the routine hourly equivalent operating sound level from regulated equipment will comply with Maine DEP sound level standards that are applicable to the Project.

Maintenance of the Project will include activities such as machinery inspections, lubrication, occasional repairs and overhauls, and painting. Maintenance activities are not expected to produce significant off-site sounds that will be intrusive to neighbors.

7. Noise Abatement

The Applicant is committed to designing and installing project equipment that complies with the Maine DEP sound level standards and to operate the project as a good acoustic neighbor. Measures to mitigate potential noise impacts associated with construction, operation, and maintenance of the proposed Project include the following:

- Effective exhaust mufflers in proper working condition will be installed on all engine-powered construction equipment. Mufflers found to be defective will be replaced promptly.

- Construction contractors will be required to ensure that their employee and delivery vehicles are driven slowly and responsibly when entering and leaving the project site.

- Construction activities will be limited to the daytime hours from 7:00 a.m. to 7:00 p.m. or daylight hours, whichever is longer. Most often construction work will stop by 7 p.m.

- The project electrical transformer will be specified for high efficiency and reduced sound levels.

- Sound level specifications will be included in the bidding and purchase documents for new noise producing equipment.

- Employees and drivers bringing trucks to and from the project sites will be instructed and required to drive slowly and responsibly when entering and leaving the site.

- The sound from wind turbines increases as wind speed increases as does the ambient sound from wind in the trees. The increased ambient sound helps to mitigate (or mask) the perceived sound from the wind turbines.

8. Noise Impact Assessment

Outdoor construction activities associated with the proposed Project will be limited to daytime hours from 7:00 a.m. to 7:00 p.m. or daylight hours, whichever is longer. Most often construction work will stop by 7 p.m. Construction sounds will vary from hour-to-hour and from day-to-day, depending on the equipment in use and the operations being performed at the site. The temporary sound associated with construction of the Project will be similar to the sound produced during construction activities at many other building projects. All equipment used in these activities will comply with applicable federal noise regulations.

The Project wind turbine generators will operate during windy conditions. It is expected that regulated equipment during routine operation will produce sound levels that are equal to or lower than the applicable sound level limits contained in Chapter 375.10 of Maine's Site Location of Development Law Regulations. See Sections 5 and 6 of this report for a more detailed discussion.

Maintenance of Project equipment will be performed so as to not produce significant off-site sounds that will be intrusive to neighbors. Neighbors may at times hear sounds associated with construction, operation, or maintenance of the Project, but the sound levels from the facility will be in compliance with applicable requirements.

9. Conclusion

The Applicant's wind turbine generator project is being designed and will be constructed, operated, and maintained so as to comply with applicable provisions of Chapter 375.10 (Control of Noise) of Maine's Site Location of Development Law Regulations.

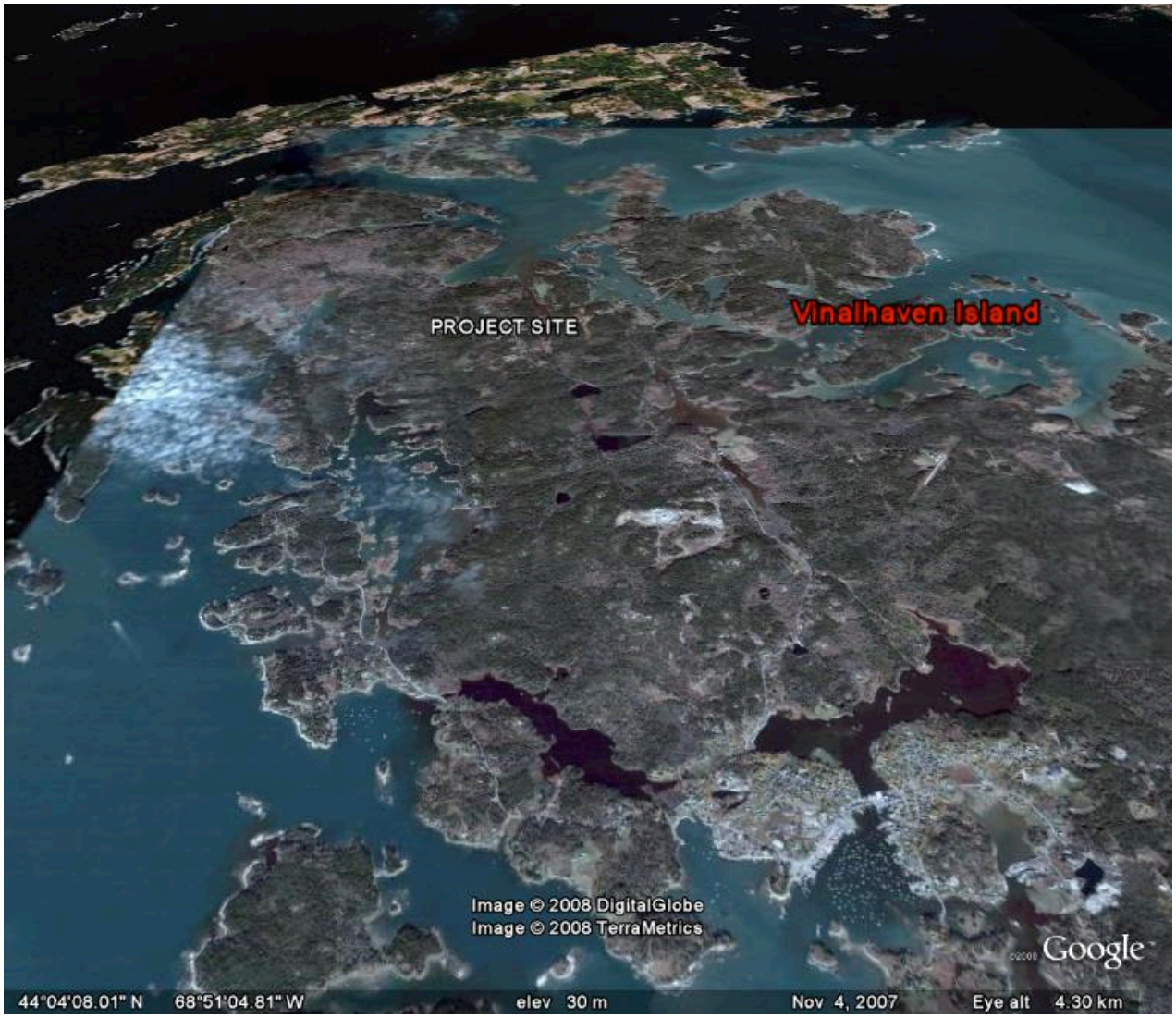

Figure 1. Aerial View of Vinalhaven Island and Location of Project Site

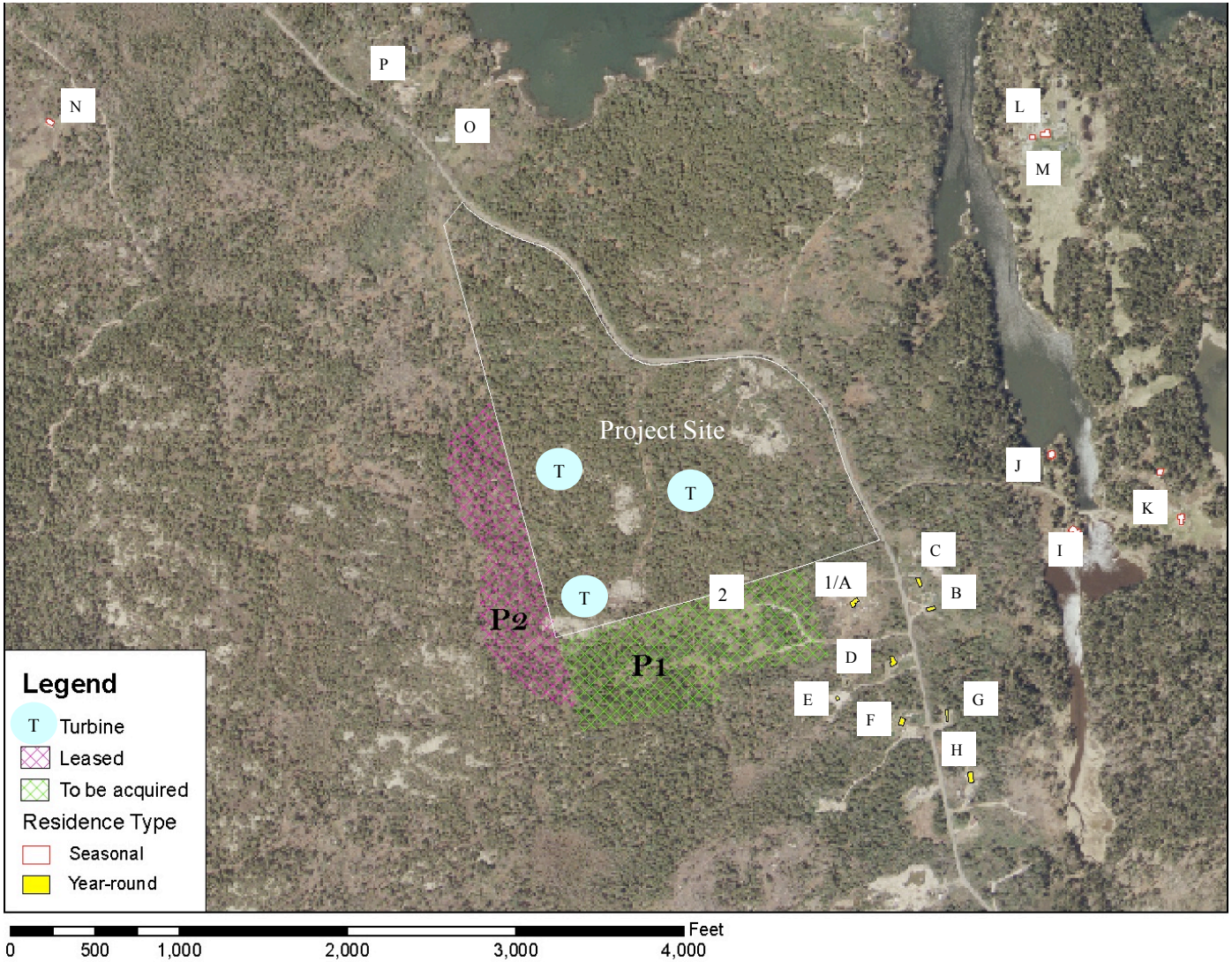

Figure 2. Aerial View of Project Site, Three Turbine Locations, 16 Residences, and Two Measurement Locations

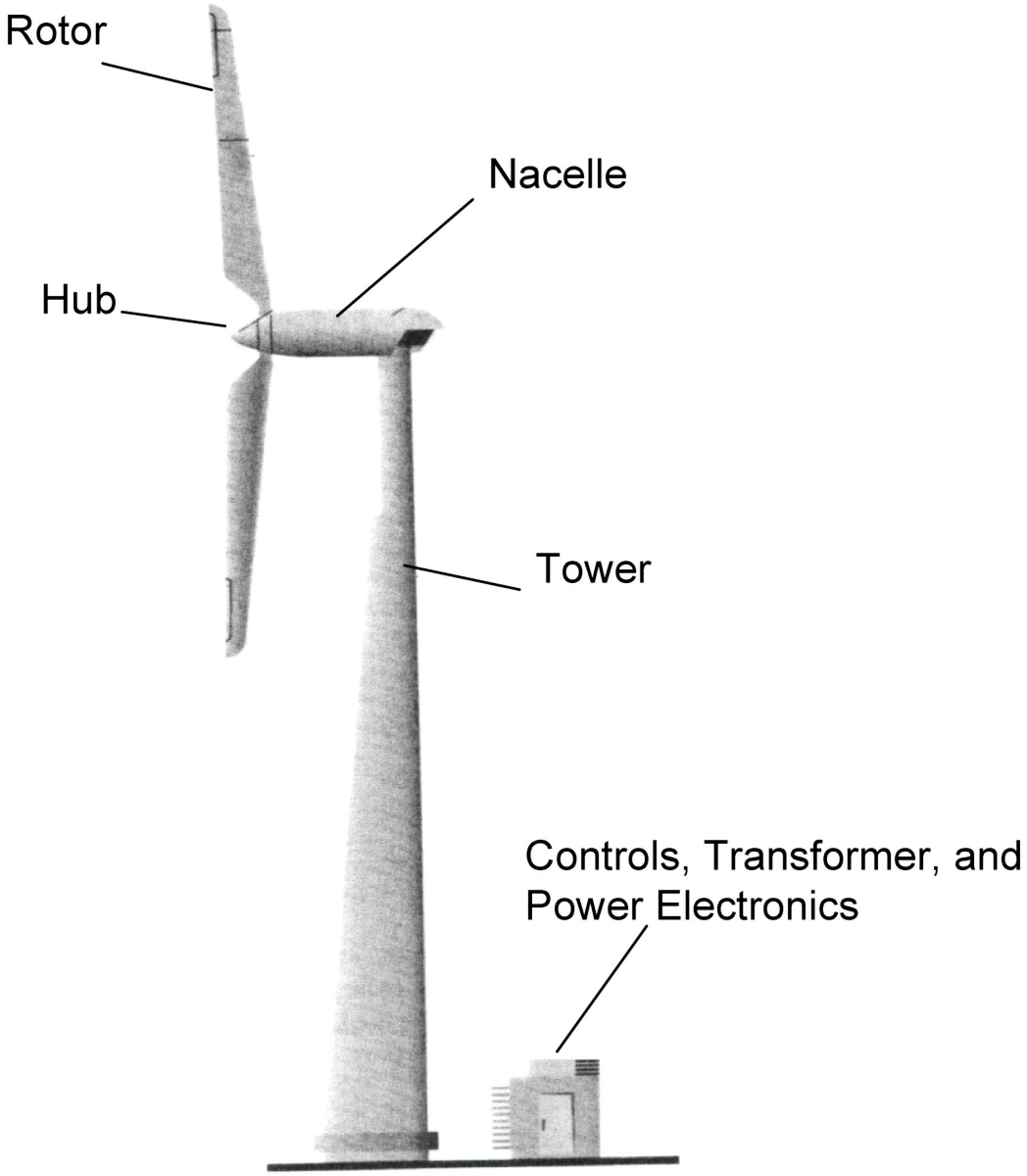

Figure 3. Wind Turbine Generator Illustration and Component Parts

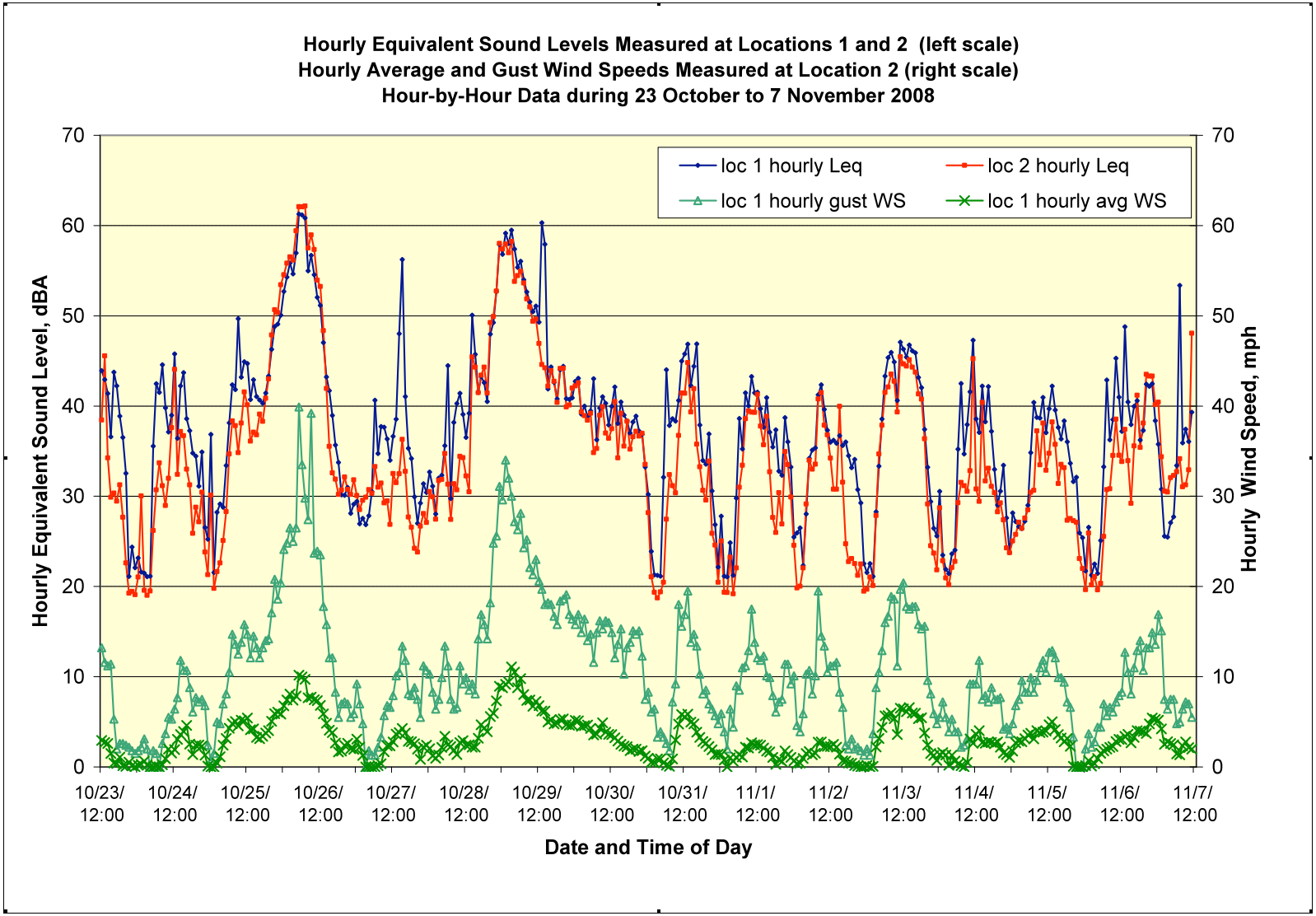

Figure 4. Hourly Measured Baseline Sound Levels and Wind Speeds at Locations 1 and 2 Adjacent to Project Site

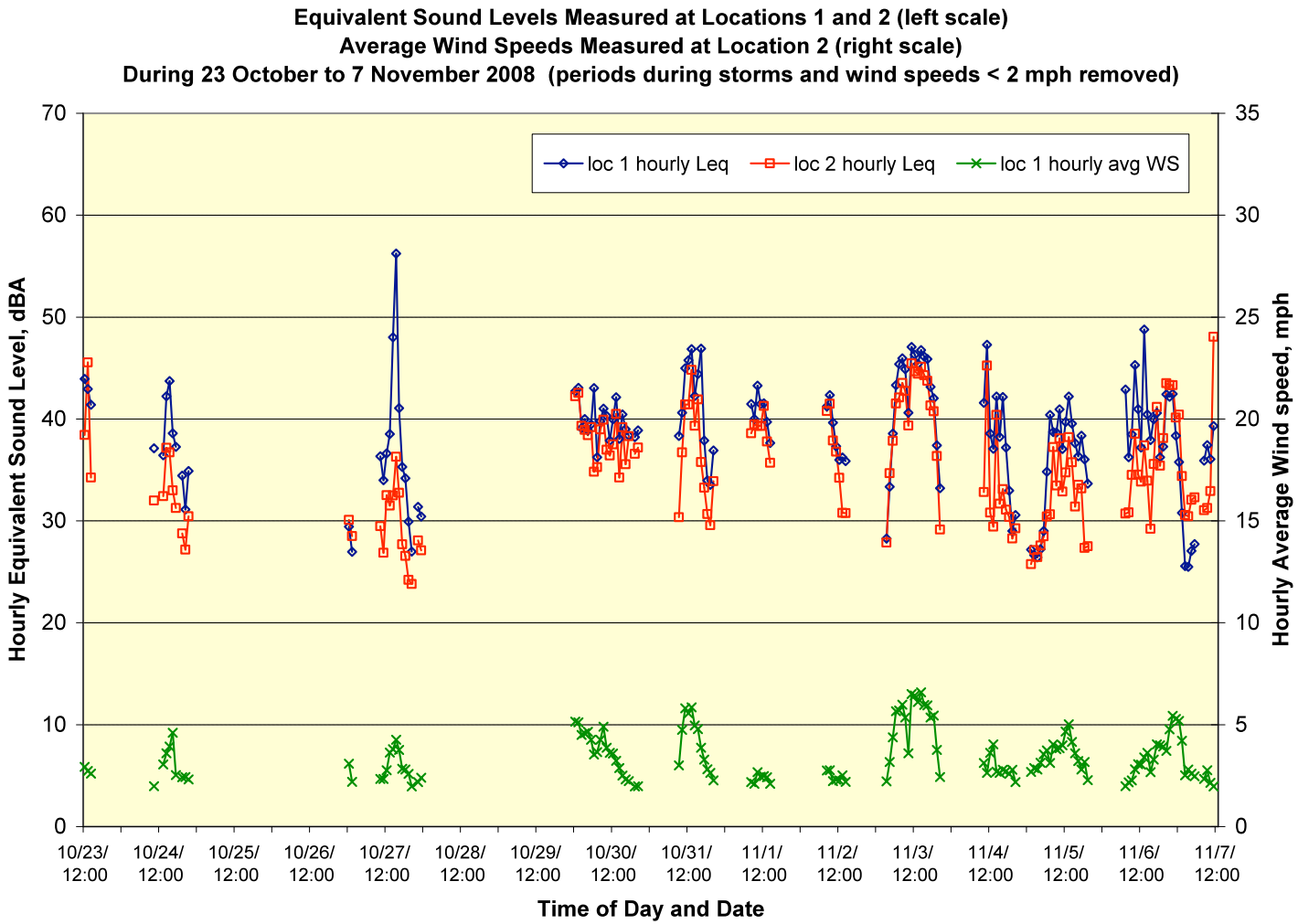

Figure 5. Hourly Sound Levels and Wind Speeds at Locations 1 and 2 without Storm and Calm Wind Conditions

Table 1. List of Instruments Used during Measurements

Instrument	Mfg	Model	Serial Number
Precision Sound Level Monitor	Larson Davis	LD-870	0160
Precision Sound Level Monitor	Larson Davis	LD-870	0163
Precision Sound Level Monitor	Larson Davis	LD-870B	1177
Pre-amp	Larson Davis	900B	4076
Pre-amp	Larson Davis	900C	1445
Microphone	B&K	4176	2026930
Microphone	B&K	4189	2542908
Calibrator	GenRad	1987	146545004

Table 2. Representative Construction Equipment Equivalent Sound Levels

Equipment	Sound Level in dBA at 1000 ft
Truck	46
Dozer	48
Excavator	52
Loader	50
Grader	48
Backhoe	50
Crane	46
Compressor	46
Pump	45
Generator	48
Welder	40
Roller	48

APPENDIX A. Sound in Lay Terms

Appendix A. Sound in Lay Terms

Sounds we hear come from small pressure oscillations, or sound waves, that travel through the air and actuate our hearing mechanism. These airborne pressure oscillations cause the eardrum and small bones of the middle ear to vibrate. These vibrations are transmitted to the fluid-filled cochlea of the inner ear's sensory organ. Sensory hair cells then transduce these vibrations into nerve impulses that are transmitted to the brain where they are perceived and interpreted.

Noise is often defined as unwanted sound and the degree of disturbance or annoyance of an intruding noise depends on various factors including the magnitude and nature of the intruding noise, the magnitude of the background or pre-development ambient sound present without the intruding noise, and the nature of the activity of people in the area where the noise is heard. For example, people relaxing at home generally prefer a quiet environment, while factory employees may be accustomed to relatively high noise levels when at work.

The magnitude, or loudness, of sound waves (pressure oscillations) is described quantitatively by the terms sound pressure level, sound level, or simply noise level. The magnitude of a sound is measured in decibels, abbreviated dB. Decibels are used to quantify sound pressure levels just as degrees are used to quantify temperature and inches are used to quantify distance. The faintest sound level that can be heard by a young healthy ear is about 0 dB, a moderate sound level is about 50 dB, and a loud sound level is about 100 dB.

Sound level meters are usually equipped with electronic filters or weighting circuits, as specified in ANSI S1.4 - 1983, for the purpose of simulating the frequency response characteristics of the human ear. The A-weighting filter included with essentially all sound level meters is most commonly employed for this purpose because the measured sound level data correlate well with subjective response to sounds. Sound levels measured using the A-weighting network are designated by dBA.

Sound energy spreads as it travels away from its source causing the sound level to diminish. Other factors that reduce sound levels include absorption in the atmosphere, diffraction and refraction in the atmosphere, terrain, and forests.

The frequency of a sound is analogous to its tonal quality or pitch. The unit for frequency is hertz, abbreviated Hz (formerly cycles per second or cps). Thus, if a sound wave oscillates 500 times per second, its frequency is 500 Hz. The fundamental frequency of Middle C on a piano keyboard, for example, is 262 Hz. However, most sounds include a composite of many frequencies and are characterized as broadband or random. The normal frequency range of human hearing extends from a low frequency of about 20 to 50 Hz (a rumbling sound) up to a high frequency of about 10,000 to 15,000 Hz (a hissing sound) or even higher for some people. People have different hearing sensitivity to different frequencies and generally hear best in the mid-frequency region that is common to human speech, about 500 to 4000 Hz.

The background or ambient acoustical environment in most communities varies from place to place and varies with time at any given location due to the composite of many nearby and distant sound sources. The ambient environment includes high sound level single-events such as the

passby of an airplane or nearby car, the barking of a dog, thunder, or a siren. The ambient acoustical environment also includes relatively steady residual or background sounds caused by sources such as distant traffic and ventilation equipment. The quantity of the single-event sounds and the amplitude of the background sounds are usually least during the late night hours from about midnight to 5:00 am. Indeed, the pre-development ambient sound level at a location is typically related to the amount of human activity in its vicinity. The amplitude statistics of this rather complex acoustical environment include the presence of a relatively-steady lower-level background and diurnal and seasonal variations.

At any location, a complete physical description of the ambient acoustical environment might include its sound level at various frequencies, as a function of time. As a first step towards simplifying this multi-dimensional description, it has become common practice to eliminate the frequency variable by measuring the A-weighted sound level (dBA), as observed on a standard sound level meter. The A-weighting filter emphasizes the mid-frequency components of sounds to approximate the frequency response of the human ear. A-weighted sound levels correlate well with our perception of the loudness of most sounds.

An increase or decrease of the outdoor ambient sound level in a community by 1 or 2 dB is generally not noticeable. Whereas a change of the ambient sound level by 5 or 6 dB is generally noticeable and an increase or decrease of the ambient sound level by 10 dB is generally considered to represent a doubling or halving of the perceived sound.

To evaluate noise impacts and report time-varying ambient sound levels it is common practice, using the A-weighted scale, to measure the equivalent sound level and the day-night sound level. The equivalent sound level is the level of a steady-state sound that has the same total (equivalent) energy as the time-varying sound of interest, taken over a specified time period. Thus, the equivalent sound level is a single-valued level that expresses the time-averaged total energy of the entire ambient sound energy. It includes both the high sound level single-event ambient sounds and the relatively steady background sounds. The day-night sound level is simply the average equivalent sound for 24-hours after 10 dBA has been added to the nighttime sound levels from 10 pm to 7 am. Adding 10 dBA to the nighttime sound levels accounts for people's expectation that nighttime be a quiet period. The day-night sound level is calculated in accordance with the following relationship

$$\text{Day-night sound level} = 10 \log\{[15(10^{0.1L_d}) + 9(10^{0.1L_n+10})]/24\}$$

where L_d is the equivalent sound level during daytime hours (7 a.m. - 10 p.m.) and L_n is the equivalent sound level during nighttime hours (10 p.m. - 7 a.m.).

The annual day-night sound level has been selected by the U.S. Environmental Protection Agency as the best descriptor to use for the purpose of identifying and evaluating levels of environmental sound.

The hourly equivalent sound level has been selected by the Maine DEP and identified in Chapter 375.10 of Maine's Site Location of Development Law Regulations as the descriptor to be used in the measurement and evaluation of sound from regulated equipment proposed for new developments.